Saskatchewan Agriculture

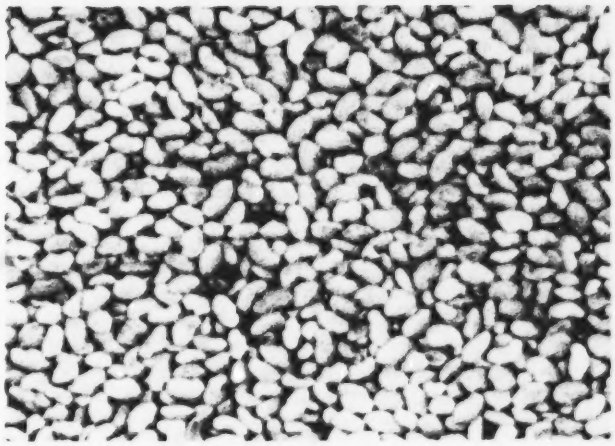
Soils and Crops Branch

# Alfalfa Seed and Leafcutter Bee Production in Saskatchewan

## Introduction

Alfalfa seed production is a small but well-established industry in Saskatchewan. In 1986 some 18,000 acres were devoted to pedigreed alfalfa seed production, with a similar amount estimated to be in common seed production. In addition to seed, many growers market surplus leafcutter bee larvae.

Alfalfa is a unique crop. Successful seed production requires a blend of farming, beekeeping, and marketing skills. This bulletin is intended as a summary "checklist" of topics a new or prospective grower should investigate. Because of the complex nature of the crop and the unpredictability of the forage seed market, new growers should contact experienced growers, extension personnel and seed dealers before making any decisions.



*The goal: clean, healthy alfalfa seed.*

## Important Organizations

There are a number of organizations with which the new grower should be familiar. They are:

The **Saskatchewan Alfalfa Seed Producers Association** (SASPA) represents alfalfa seed and leafcutter bee producers, and acts as a liaison between Saskatchewan producers and the seed trade, the Provincial Government and Federal Government on matters of industry concern. The Association disseminates technical information to its members through newsletters, field days and meetings.

The **Canadian Alfalfa Seed Council** is an umbrella organization representing the three prairie alfalfa seed producer organizations. It oversees the operation of the Canadian Cocoon Testing Centre at Brooks, Alberta.

**SeCan** is a nationwide organization that promotes and markets Canadian pedigreed seed varieties. Growers can obtain general SeCan varieties directly, or contract with other SeCan growers who hold exclusive or restricted varieties. To obtain a general variety, the grower must become a SeCan member before December 31, the year prior to the year he/she plans to plant the variety.

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**Canadian Forage Seed Project** is a joint Federal/Provincial organization that sells foundation seed of public varieties. No membership (other than CSGA—see below) is required. Seed is presently available through Saskatchewan Agriculture's Forage and Range Management Specialist.

**Saskatchewan Agriculture's** Leafcutter Bee Specialist is located in Prince Albert; the Provincial Forage and Range Management Specialist is in Regina.

Other organizations of interest to the grower are the **Canadian Seed Trade Association,** representing the commercial seed trade, and the **Canadian Forage Council,** an umbrella body that lobbies on behalf of forage growers.

Addresses for these organizations will be found at the back of this pamphlet.

## Pedigreed Seed Production

Growers wishing to produce certified seed must conform to **Agriculture Canada** (CDA) Seeds Act regulations. **The Canadian Seed Growers' Association** (CSGA) is responsible for matters relating to the maintenance of crop pedigree, such as field isolation and sanitation.

When a grower completes an "Application for Field Inspection," he/she automatically becomes a member of CSGA. Note that the deadline for applying for inspection of forage seed fields is June 10 of the first year of seed production.

## Choosing the Right Field

Alfalfa tolerates a wide range of soil types. Many growers report that sandy land with a high water table, while not ideal for other crops, is quite acceptable for alfalfa. Land that floods for more than a few days at a time should be avoided. In general, the best land will produce the best seed crop. Leafcutter bees are less active under windy conditions, so fields that are sheltered by trees are a good choice. In addition, swaths are less likely to blow if the field is sheltered. Fields of pedigreed varieties must be isolated from each other, and pedigreed fields must be isolated from non-pedigreed fields. Consult the CSGA Bulletin **Regulations and Procedures for Pedigreed Crop Production** for further details.

If you plan to manage your own bees, remember that it is a labour-intensive activity, and a convenient field location is an asset.

Weed control in alfalfa is expensive and may not be completely successful, so starting with a clean field is essential. The most recent **Canada Seeds Act Regulations** prohibit **any** level of contamination of certified alfalfa seed by the weeds listed in Table 1. Growers should familiarize themselves with these weeds and avoid them at all costs.

**Table 1**
**Prohibited and Primary Noxious Weed Seeds for Certified Alfalfa Grade as of July 1, 1987.**
Species important in Saskatchewan are marked with an asterisk(*).

| | |
|---|---|
| Dodder | Greasewood |
| Field bindweed* | Golden-bean |
| Halogeton | Low larkspur |
| Hoary cress | Tall larkspur |
| Horse nettle | Seaside arrow grass |
| Leafy spurge* | Jimson weed |
| Russian knapweed | Common crupina |
| Tansy ragwort | Yellow starthistle |
| Red bartsia | Couchgrass* |
| Diffuse knapweed | Great ragweed |
| Spotted knapweed | Ox-eye daisy |
| Nodding thistle | Perennial sow-thistle* |
| Poison hemlock | Wild mustard* |
| Death camus | Wild radish |
| White camus | Yellow rocket |
| Western water hemlock | Bladder campion* |
| Narrow-leaved milk vetch | Toadflax* |
| Two-grooved milk vetch | White cockle* |
| Timber milk-vetch | Canada thistle* |
| Early yellow locoweed | Bedstraw (Cleavers)* |
| Silvery lupine | Velvet leaf |
| | Johnson grass |

Source: Canada Seeds Act

In addition, seeds of certain other weeds, such as sweet clover, black medic and night-flowering catchfly, while not Prohibited or Primary noxious, are difficult to separate from alfalfa seed. Fields contaminated with any of these weeds should be avoided.

## Seedbed Preparation

A firm, clean seedbed is essential for a good seedling stand. Packing before seeding is useful, to provide a firm bed to seed into. Most fields are seeded on summerfallow, but stubble can be seeded if the land is free of weeds.

Spring seeding is the most common, from May to early June. A few growers have tried late fall seeding just before freezeup. This is not recommended if the field is prone to wind erosion over the winter.

## Seeding Rates and Row Spacing

There is a wide variation in seeding rates used in Saskatchewan, from 0.5 pound per acre up to 2.5 pounds per acre. Research suggests that the optimal rate is between 0.5 and 1 pound per acre. Row spacings also vary widely: growers in the Parkland area use 6, 12, or 18-inch row spacings, while growers in the south go to 3-foot spacings. In general, as moisture (and weeds) increase, row spacings should decrease. Wider row spacings provide some opportunity for inter-row cultivation after the crop is well established.

Manitoba research has shown that highest seed yields are obtained with established plant populations of about 22,000 plants per acre (using 24 inch row spacing), or roughly 2 square feet for each plant. Even at the low seeding rates suggested above, thinning may be useful to maintain optimum plant populations on older stands.

Broadcasting is used by some growers, particularly in wet fields, but it has disadvantages. Germination rate is usually lower than in drilled seedings, and inoculation is not as successful. If broadcasting is used, both seeding and inoculation rate should be increased.

**Seeding depth is critical; it should not be more than one half inch in most soils. On sandy soils placement can be slightly deeper. Disc press drills are commonly used for seeding alfalfa, but many types of seeders are successfully used, so long as they can handle low seeding rates and have good depth control.**

## Fertilization

Little is known about optimum soil fertility for alfalfa seed production. Pending further research, the grower is well advised to sample fields prior to seeding, and follow soil test recommendations.

Some nitrogen may be added before seeding, but properly inoculated alfalfa plants will look after their own nitrogen needs. Phosphorus levels should be maintained, since alfalfa is a heavy user of this element. Sulfur may become limiting in the coarse and medium-textured soils of the Parkland region. Adequate boron is necessary for optimum flowering, nectar secretion and seed set; however, excess boron may be detrimental.

## Inoculation

Inoculation should be practiced every time you seed. Make sure you buy alfalfa-type inoculant (double-check the container when you purchase it) and keep the inoculant cool at all times.

Use a sticking agent to "glue" the inoculant to the seed. Syrup or molasses works well, but powdered milk has been found to be the best sticking agent. Mix the milk to about the consistency of light cream and pour just enough on to totally wet all the seed. If seeding a small amount, use a clean floor, or a plastic sheet as a mixing surface. Simply pour the sticker on, thoroughly mix the seed, and allow the excess to drain off. Then pour the inoculant on, and mix again thoroughly. The seed will now flow easily and can be seeded immediately.

For large amounts of seed, augers do a good job of mixing seed, inoculant and sticker together.

Never skimp on inoculant. If seeding conditions are not ideal, do not hesitate to double or even triple the recommended rate. Good nodulation is essential to a healthy, productive alfalfa stand. To check a field for nodulation, examine the roots in June, before flowering begins. Swollen, pinkish-colored nodules should be evident.

*Legume inoculation is essential. Make sure you get the alfalfa variety, and use a sticking agent.*

## Companion Crops

Companion crops have advantages and disadvantages. In general, conditions of a) good soil moisture, b) high weed populations and/or c) wind erosion potential all point to the use of a companion crop. When these conditions are not present, companion crops are not recommended.

A companion crop should be seeded at half (or less) the normal seeding rate, either at right angles to the alfalfa or in alternate rows. A separate seeding operation, at right angles, is ideal, since it minimizes competition and allows each crop to be seeded to its optimum depth.

Flax is the least competitive and therefore the first choice of companion crop, but it will limit the producer's herbicide options. If wheat or barley are used, they may be taken off early as greenfeed, to allow the alfalfa to develop in late summer. Canola crops should be harvested early, and volunteer canola plants must be removed from the field in subsequent years.

One Manitoba study compared alfalfa seed production with and without a rapeseed companion crop. In the spring of 1979, Algonquin alfalfa was seeded alone at 1/2 pound per acre in one plot, and together with rapeseed at five pounds per acre in another. Rapeseed was combined at maturity and the straight alfalfa plot was cut for hay in mid-August. The subsequent-year seed yields are set out in Table 2.

Recent trials by Waddington and Malik in Melfort produced results that differed from the Manitoba study. Using Beaver Alfalfa and Candle Polish rape together in a number of different seeding arrangements, the researchers found no consistent differences in alfalfa seed yield when compared to straight alfalfa control plots. They suggest that Polish rapeseed can be used successfully as a companion crop in northeastern Saskatchewan, but further study is required to determine optimum seeding rates.

Growers should also be aware that the Canada Seeds Act sets very low tolerance standards for seeds of the Brassicas (mustard, rape, Canola, etc.) in alfalfa seed. For example, for Certified #1 alfalfa, only four Brassica seeds are allowed per 25 grams of alfalfa seed.

If a straight alfalfa stand is strong and vigorous it may be cut for hay the first year, but **only** after growth has stopped in the fall.

**Table 2**
**Performance of Alfalfa Seed Plots Seeded With and Without a Rapeseed Companion Crop**

| Companion Crop | Establishment Year Yield (Seed or Forage) | Alfalfa Seed Yield | |
|---|---|---|---|
| | | First Seed Year (lbs/acre) | Second Seed Year (lbs/acre) |
| Rapeseed | 25 bus/acre | 210 | 428 |
| None | 0.9 tons/acre* | 308 | 472 |

* Hay crop cut in mid-August

Source: Alfalfa Seed Production Management in Manitoba, Manitoba Alfalfa Seed Producers' Assn., 1984.

## Weed Control

There are few chemicals registered for use in seedling alfalfa fields. The preplant wild oat herbicides are generally effective. Broadleaf weed control can be achieved with Asulox F or 2,4-DB, but growth of the alfalfa seedlings is frequently slowed for a time. Herbicide recommendations change frequently; the current **Chemical Weed Control in Cereal, Oilseed, Pulse and Forage Crops** should be consulted for specific information.

A number of unregistered herbicides are used in alfalfa, but the practice is risky and the manufacturers are not responsible for losses occuring from unregistered use. Growers wishing to try an unregistered chemical should contact the manufacturer's representative for technical advice.

Research is currently under way to develop more specific recommendations for chemical weed control in alfalfa seed fields.

Depending on row spacings and available equipment, established alfalfa fields may be cultivated to control weeds. This should be done carefully to avoid damage to the alfalfa roots or crowns.

## Insect Pests in Alfalfa

The major insect pests of alfalfa grown for seed production in Saskatchewan are lygus bugs and alfalfa plant bugs. Pea aphids and grasshoppers may occasionally reach economically damaging levels. Insect pest management programs have been developed for seed alfalfa which emphasize weekly monitoring of fields and insecticide treatment only when warranted.

Alfalfa plant bugs overwinter as eggs in stems and stubble, while lygus bugs winter as adults in surrounding bush, headlands and shelterbelts. Burning fields in the spring is a very effective means of controlling alfalfa plant bug, but care must be taken that the alfalfa crowns are still dormant when burning is done or growth will be set back. Lygus adults migrate into fields during May; the females lay their eggs in alfalfa stems and the young nymphs first appear from early to mid-June. Alfalfa plant bug nymphs appear somewhat earlier. Both insects feed by piercing the plant tissue and sucking plant juices, and both prefer rapidly growing tissue such as buds and new pods. Each progresses through five nymphal stages; new adults appear in July. The late nymphal and adult stages are the most damaging to the crop. If large numbers go unchecked, alfalfa plant bug can destroy most of the flower buds in a field, while lygus bug can cause damage to developing buds, seeds and pods. Monitoring by means of a sweep net will indicate the numbers and progression of each population. If numbers warrant treatment, timing is aimed at the third nymphal stage in order to achieve control before the more damaging fourth and fifth nymphal stages appear in any number.

Aphids are also plant juice feeders, congregating on stems and causing general plant damage, including loss of vigour and premature drying. Grasshoppers feed on all plant parts. Both insects should be monitored throughout the summer in order to determine if numbers warrant chemical treatment.

Further information on monitoring and control of these insects is available from Saskatchewan Agriculture and from the Saskatchewan Alfalfa Seed Producers Association.

## Harvesting, Cleaning and Storage

After pollination, alfalfa seeds take about five to six weeks to mature. If the crop is to be swathed, this operation may begin when most of the seed pods have matured and are brown or black in color. Some additional ripening will occur in the swaths, which require 7 to 10 days minimum drying time.

Alfalfa swaths are light and fluffy, and very prone to blowing. To minimize damage, swath rollers are recommended, as is orienting the swaths parallel to prevailing winds.

Straight combining is a popular option that reduces seed losses. A variable-speed pickup reel is useful for straight combining. By adjusting reel speed, the producer can minimize the amount of seed stripped off as the crop is taken into the combine.

Straight combining is usually done in conjunction with chemical desiccation of the crop, which speeds drying. Very little seed ripening occurs after desiccation so most of the pods should be mature already before spraying. Combining usually takes place 10-14 days after treatment.

A hard frost will effectively desiccate an alfalfa seed crop. Some farmers will wait for a killing frost up to a certain date, and then switch to desiccation or swathing if frost has not arrived.

The extent of combine modification will depend on whether the machine will be used strictly for alfalfa or for grain crops as well. Check with a dealer for specific recommendations on your particular combine make and model. Leakage from the combine can be a problem given the small size of alfalfa seed: it is a

good idea to plug all leaks (flexible caulk and a caulking gun works well) to avoid losses.

Slow ground speed is advisable while combining, as is frequent monitoring of the chaff for seed loss.

The crop aftermath may be chopped and spread on the field, baled up, or burned. Most producers feel the best practice is chopping and spreading, in order to maintain soil nutrients and organic matter. Spring burning provides some protection against insect and pathogen buildups. Burning must be done before greenup, to avoid stand damage.

Seed moisture levels in excess of 13 or 14 percent will require drying before storage. In general, if seed separates from the pod readily during combining then heating will not be a problem during storage.

New growers should be aware that alfalfa is a difficult crop to thrash. Conventional grain crops present few harvesting problems when compared to alfalfa.

# Alfalfa Leafcutter Bees

## Introduction

Alfalfa leafcutter bees (**Megachile rotundata**) are necessary for optimum seed set of alfalfa. The bees collect alfalfa pollen as a feed source, and in doing they transfer some pollen from the flowers of one plant to the flowers of another. This process, called cross-pollination, is necessary for seed set in alfalfa.

The alfalfa leafcutter bee was first introduced into Saskatchewan in the early 1960's. Before that, alfalfa seed was produced mainly in the northeastern agricultural areas, and pollination of the crop was carried out mainly by native leafcutter bees and bumble bees. Crops fluctuated widely from year to year. The introduced leafcutter bee has supplemented and to some extent replaced native pollination. It has extended the boundaries of the alfalfa seed producing region and has allowed a more constant production. Experimentation by research and extension personnel and growers has resulted in the development of today's management techniques.

The seed grower must decide whether to purchase leafcutter bees and become involved with bee management or to contract out the pollination to a leafcutter beekeeper. Management of bees is very labour-intensive throughout the growing season, and a substantial capital expenditure is initially necessary. Leafcutter bee populations do tend to increase each year, and while the sale of extra leafcutters will offset start-up and operating costs, markets are difficult and time-consuming to establish. Contracting with a leafcutter beekeeper is on a crop-share basis. If the contracting route is chosen, the grower and beekeeper need to establish the management responsibilities of each and the cost share arrangements. Sample contracts are available from Saskatchewan Agriculture.

## Bee Biology

The leafcutter bee goes through the four life stages common to many insects; egg, larva, pupa and adult. Once the egg hatches, the young grub-like larva begins to feed on pollen and nectar provisions left by the adult female. It grows and moults until it reaches its full size, and then spins a cocoon of fine silk-like threads, which harden to become a protective water-resistant covering. The full-sized larva within its cocoon then enters the prepupal resting stage, called diapause. Once winter passes, the prepupa resumes its development, moults again to the pupal (immature adult) stage, and then develops into an adult bee. The new adult chews through its cocoon and leaf cappings and emerges from its cell. Adult males begin emergence several days before females, and the ratio of male to female is generally about 2:1. Mating occurs soon after the females emerge, and both males and females forage for nectar from nearby blossoms. The female begins nesting almost immediately, in sites such as tunnels in logs, holes and crawl spaces in buildings, or appropriate nesting material supplied by the grower. The female begins constructing and provisioning the cell; she cuts oval leaf pieces from such plants as alfalfa, buckwheat and rose and uses them to line the tunnel, cementing them together with saliva. She then collects pollen and nectar to form a moist pollen ball in the cell.

*Leafcutter bee female.*

The bee lays a single egg on the pollen ball, cuts more round leaf pieces to cap the cell over, and begins the whole process again on top of the first cell. Once a tunnel is full of capped cells, generally from 8 to 11 in standard nesting material, the female cuts more leaf pieces and cements them in place to form a plug. The first eggs in each tunnel are female; subsequent eggs are male.

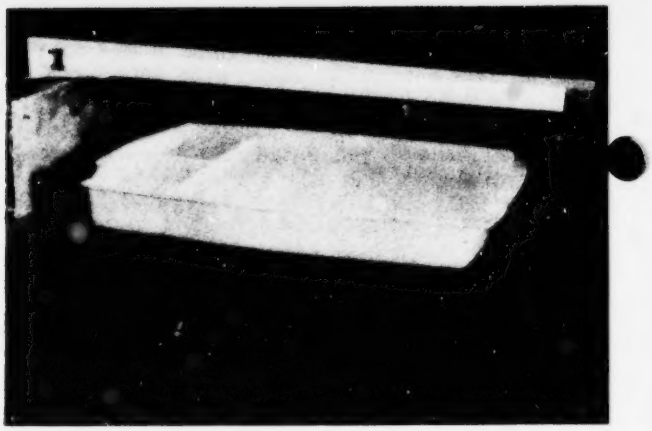
## Obtaining Leafcutter Bees

Leafcutter bees are generally purchased during the fall, winter or early spring as prepupae in diapause. Bee populations vary in quality. Some of the criteria of quality are: live count per pound or kilogram, male:female ratio, presence of pollen balls, presence of parasites and diseases, and presence of mold in or on cocoons. These criteria can be determined in a number of ways. The Canadian Cocoon Testing Centre offers sample analysis on a fee-for-service basis which gives a breakdown of the sample quality. Many beekeepers use this service. In addition, many beekeepers routinely sample their bee populations in the autumn and cut open cocoons in several pre-weighed subsamples, separating the cocoons into appropriate categories and calculating a live count from the results. A small incubator is needed to determine the sex ratio, since the prepupae must develop into adults before their sex can easily be determined. The leafcutter bee buyer can ask to see the results of the Brooks test on the bees he/she considers purchasing. The buyer is also well advised to sample the bees on the spot and to cut open 4 - 1 oz. subsamples to determine the live count and the presence of parasites, disease and mold. Parasites and chalkbrood disease are potentially devastating problems which can be avoided through judicious acquisition of leafcutter bees. Local purchase from a known beekeeper may be more sensible than long distance or out-of-province purchase. **It is illegal to import leafcutter bees and/or used nesting material from other countries.**

## Parasites, Diseases and Predators of Leafcutter Bees

The most common parasite in Canadian leafcutter bee populations is **Pteromalus venustus**, a small wasp which lays eggs through the leaf covering of the cell onto the developing immature bee. The parasite larvae consume the immature leafcutter, then may go into diapause or may develop and hatch out as adults.

Prevention and control methods involve firstly the purchase of parasite-free bees, a condition which can be determined through sampling. Parasites are most easily controlled during incubation. Black lights (CGE F20T12/BL or BLB) are used during incubation to attract adult parasites out of the incubation trays; a container of water with surfactant added is placed under each black light to trap and drown the parasites. Regular vacuuming of the edges of trays, supports, and other surfaces where parasites are seen will also help to reduce the problem. Insecticide vapour strips are effective in parasite control. Strips are hung in the incubator when the first parasites are seen, about day 8, and are removed by day 13 of incubation. The incubator is then thoroughly aired for 24 hours before incubation is begun again. The recommended rate is 1/2 to 3/4 strip per 1000 $ft^3$. Caution is advised when using these strips, as lingering vapours may cause bee mortality.



*Parasite control: ultraviolet light over water bath.*

Other species of parasitic wasp which may occasionally be found in leafcutter bee populations are **Melittobia chalybii** and **Monodontomerus obscurus**. Both are controlled by the methods described above.

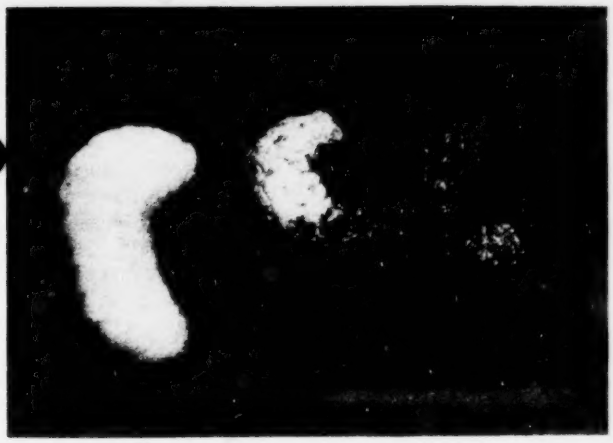
Chalkbrood disease (**Ascosphaera aggregata**) is a fungus disease present in leafcutter bee populations in parts of the prairie provinces and the Northwestern United States. Young larvae consume chalkbrood spores which germinate and grow in the gut, causing eventual death. Cadavers appear a brassy, light-brown color (nonsporulating) or a very shiny, cellophane-covered black color (sporulating). Adults are not affected, but females can contaminate the pollen balls they provide for their young. The disease is easily spread throughout an area by spore dispersal and adult bee drift, and among areas through purchase of affected leafcutter bees and used nesting material.

**If left unchecked, this disease can decimate leafcutter populations.** The best known prevention is to avoid purchasing contaminated bees and equipment. Bleach treatment of cocoons, nesting material and other equipment is effective in controlling chalkbrood. Nesting boxes (tunnel openings up) and cells are submerged for 3-5 minutes in a 5% bleach (sodium hypochlorite) solution with 0.1% surfactant added. The solution concentration should be monitored using a bleach test kit.

## Nests

Leafcutter beekeeping requires the purchase and/or construction of specialized nesting boxes, field shelters, incubation and storage facilities, and cocoon removal apparatus.

The first decision to make is whether to purchase wood or polystyrene nesting material. Wood is more expensive and heavy, making handling less easy than polystyrene, which is less expensive and lighter in



*Chalkbrood: (L) healthy prepupa, (M) nonsporulating cadaver, (R) sporulating cadaver.*

weight. However, wood is more durable than polystyrene. Wood is less prone to surface mold buildup. However, polystyrene can be treated each year with bleach solution to control chalkbrood and mold problems, while wood may tend to warp and crack when dipped unless it is tightly clamped.

The grower must also decide whether to use nesting laminates or drilled blocks. Both are available in wood and polystyrene. While blocks are easier to handle, the beekeeper must remember that cell removal from nesting material each fall is of paramount importance for proper disease, mold and parasite control. Cell removers are available to strip drilled blocks, but unless the blocks have been thoroughly dried, some damage to the cells will result. Blocks with blind holes are not recommended.

Used nesting material is often available for purchase. The beekeeper must weigh quality and price of new against used nesting material, remembering that with used material comes the possibility of disease. Used nesting material should always be thoroughly cleaned and dipped in a bleach solution before using.

Nesting boxes are constructed to accommodate the width and depth of the laminate or block, with the length adjusted for the number of laminates or length of block desired. Box length must also accommodate the rack design in the field shelter. Boxes must be of tight and durable construction so that predaceous and parasitic insects cannot get in. The backs of the nesting boxes are generally made of water absorbent material; a combination of hardboard and a layer of foam may be used, or the backs may be made of tentest.

Nesting material is held tightly together and against the backs of the boxes by nailing wood strips along each side and using some type of spring at the top, to compress and hold together the nesting laminates.

## Shelters

Shelters protect the adult leafcutters and the developing immatures from wind, rain and direct sun. Depending on latitude, shelters can be designed to be cooler or warmer than ambient air temperatures. Many shelter designs are used, including simple 4' X 4' X 8' shelters, A-frames, and enclosed greenhouse-like constructions. Variations of a 4' X 8' X 8' shelter are most common. Variations include awnings for shelter and warming, replacement of part or all of the roof and upper walls with greenhouse polyethylene for light and warmth, the inclusion of a floor, and a size increase to accommodate more nests and more adult leafcutters. A 4' X 8' X 8' shelter is generally used to hold 100,000 adult leafcutter bees, for pollination of five acres.

Racks are constructed in the shelter to hold the nests. These may consist of slats, behind which fit cleats attached to tops and bottoms of nesting boxes. Care must be taken that there is an air space between box and shelter so that excessive heating does not occur within the nest.

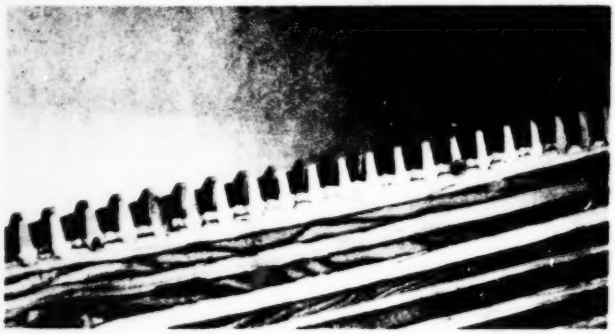
*A common shelter design in Parkland regions.*

## Incubators, Cell Removers and Tumblers

In addition to field equipment, the leafcutter beekeeper requires an incubator large enough to accommodate the leafcutter population. The incubator is a room or building equipped with thermostatically-controlled heating, cooling and air circulation systems. Within the incubator are racks to hold screened trays, in which leafcutter bee cocoons are incubated. The incubator may be designed to allow bleed-off of adult bees, into smaller trays or into a separate room where they may be kept cool pending field release.

A cell remover and a tumbler are also needed for removal of cocoons from nesting material in the autumn. Cell removers are designed around two sets of teeth between which the individual nesting laminates are pushed. The cells or cocoons are

scooped out of their grooves by these teeth, and then fall down a chute into a storage container. Cell removers with a set of plungers are also available for pushing cocoons out of solid nesting blocks. A tumbler, comprised of a cylinder of mesh or expanded metal (4.75 mm openings) and a hand crank or motor, allows removal or excess leaf material and debris, to lessen the volume of the cocoons to be stored.



*The teeth of a cell remover, used to dislodge leafcutter bee cells from nesting laminates.*

Winter storage containers for leafcutter cocoons include large black plastic bags, cardboard drums, boxes and 45 gallon steel drums. Cardboard drums with removable lids are commonly used.

## Management of Leafcutter Bees

Leafcutter bee cocoons should be stored during the fall, winter and early spring at 5 - 8° C in dry containers, in a temperature-controlled facility free of rodents and excess moisture. These storage conditions must be maintained until it is time to begin incubation.

The incubation period is about 24 days, and should begin approximately three weeks prior to the anticipated date of 10% alfalfa bloom. While this date varies from year to year, many beekeepers usually aim for a release date around July 1, and commence incubation at the end of the first week of June. Cocoons are placed in incubation trays, with screens removed, in the incubator a day or two early and allowed to warm up slowly before temperatures are increased. The optimum incubation temperature is about 29-30° C at a relative humidity of over 50%. Parasitic wasps must be controlled during incubation, especially between days 8 and 13. If insecticide vapour strips are used, once they are removed the incubator must be thoroughly aired for 24 hours before incubation is resumed, at which time the screened tops are placed on each tray. Temperature must be carefully monitored during the whole period, because developing pupae and newly-hatched adults are easily killed by high temperatures. Some producers have back-up power for their air-conditioning systems, as well as alarms which are triggered when temperatures rise. High relative humidities are essential during the hatch period for successful emergence and wing development. Adult males begin hatching around day 18 and peak around days 21-22, while adult females begin hatching around day 20 and peak around days 23-24.

In order to monitor the hatch the beekeeper can place several 100-cell samples in small compartmented trays made of fluorescent light covers and plexiglass. These samples are examined each day, and the extent of hatch of each sex noted. Release date can thus be timed to when 60-70% of the hatch is complete.

The producer may see adult bees present around day 14 or 15. These will be native leafcutter bees which have nested along with the domesticated bees and which have a shorter incubation period.

The incubation period may be lengthened by cooling the developing pupae to below 20°C before hatch is begun. Pupae develop very slowly below 20°C and can be held at these temperatures for up to ten days without harm.

While incubation is in progress, shelters and nesting boxes are placed in the fields. Shelters are oriented to the east or southeast for morning warmth and light, and are pegged and roped so that they cannot blow over. One shelter is generally allowed for every five acres, and one to two tunnels are allowed per female. Thus, at a stocking rate of 20,000 bees per acre and a male: female ratio of 2:1, there will be 6700 females, requiring from 6700 to 13,400 tunnels per acre. For five acres, each shelter will therefore need to hold enough nesting boxes to allow five times this number of tunnels, and so on. Rodent poison may be placed in each shelter to control field rodents, which can damage nests and new cocoons.

Used nesting material may be immersed in a bleach solution each year to kill fungi, yeasts and bacteria. The recommended practice is to dip each nesting box in a 5% bleach (sodium hypochlorite) solution plus 0.1% surfactant for 3-5 minutes. The box is then drained and allowed to airdry prior to bee release. The concentration of bleach should be monitored periodically with a bleach test kit. Some beekeepers also dip the leafcutter bee cocoons in this solution in order to surface-sterilize them. Cocoons must be completely dried before incubation begins. Drying is done on the shop floor, using air circulation and turning the cocoons until they feel dry. Direct sunlight should not be used for drying as it may overheat and kill the prepupae.

Once the female hatch is well underway the adult bees are released. Trays are taken to each shelter, preferably in the early morning, placed out of the direct sun and screens removed. If the bees have clumped together in the trays they should be gently shaken and prodded until they take flight. Trays may be left in each shelter, or after all the adults have left they may be brought in for re-incubation, to ensure that all of the later-hatching females are hatched and then released. In warm years enough heat units may accumulate in the field to allow final development and

hatch of these females. However, re-incubation ensures a complete hatch. To monitor field hatch, the 100-cell incubation trays may be taken out with the large trays and left in each shelter. The beekeeper will then get an indication of when field hatch is complete. Cocoon material should be removed from the field and disposed of once the hatch is finished.

If a bleed-off incubator is used, bees are released on a daily basis as weather permits. Adult bees may be held at 10° C for up to five days.

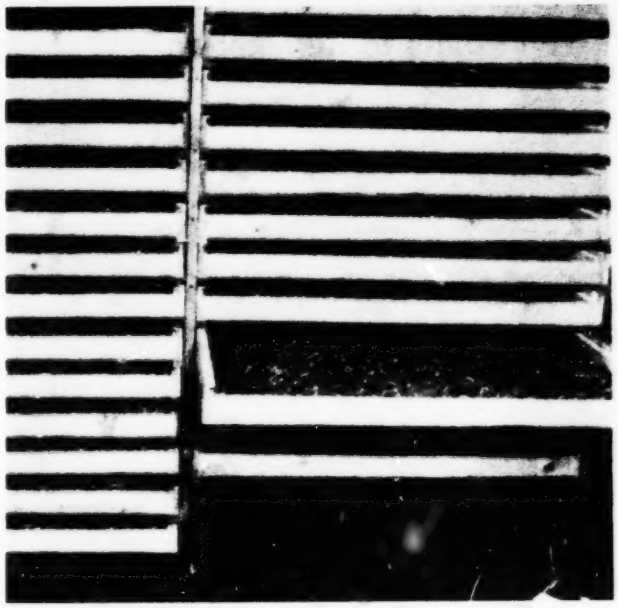
After adult bees are released, regular field checks allow assessment of nesting activity. Some drift of adult bees may occur, especially in fields that are not well-sheltered. Extra nesting boxes may be required in downwind shelters if substantial drift occurs. Nesting boxes may be exchanged at night if equalization among shelters is desired. Nesting boxes which are 70% capped before the first week of August should be replaced with new boxes. Bee activity generally decreases by mid-August, thus any new boxes will be only partially filled after that time. Nesting boxes are removed from the field during the heat of the day in order that the adults are absent from the tunnels.

Once nesting boxes are removed from the field they are stored at 20°C for at least three weeks. This period allows egg hatch, larval feeding and cocoon-spinning to be completed before the cells are removed and placed in storage. If laminates or cells feel damp to the touch the nesting material may be stood on its side, exposing the back of the nest to allow better drying. Excess moisture may enhance fungal growth, which is detrimental to the health of both leafcutter bees and beekeepers. Parasite control, by vacuuming and the use of black lights, is essential. Insecticide strips are not recommended at this time of year.

Cell removal and tumbling is done some time after the larvae have finished spinning their cocoons. Many beekeepers wait until field work is done before extracting the leafcutters. It is important to store leafcutter cocoons, whether in nests or as loose cells, at temperatures over 0°C. At no time should they be subject to subzero temperatures. The 5 - 8°C range is ideal for maintaining diapause and control of storage pest insects such as dried fruit moths and carpet beetles.

**Beekeepers should wear dust masks and maintain good air circulation during the cell removal and tumbling process. Many beekeepers become sensitized or allergic to the dust which arises from the cells. Cell removers and tumblers should be hooded or covered and vented to the outdoors.**

Once cells are ready for winter storage they may be sampled for quality and quantity determination. About one cup is taken from every five gallons of cells, and this initial sample is mixed well and then stored with the other cells pending subsampling and checking.



*Racks of incubation trays holding leafcutter bee cells.*

## Marketing of Leafcutter Bees

Leafcutter bee cocoons can be marketed as a commodity in themselves. There is usually some demand for cocoons from new and expanding growers in Canada, but the major market is currently in the United States, primarily Washington, Idaho, Oregon, Montana and Nevada. Leafcutter populations in these regions are difficult to maintain due to disease, predation, and second generation problems; thus growers require a steady input of new bees. There is also an occasional overseas sale of leafcutter cocoons.

The beginning marketer must make contact with potential buyers once the level of quality of his/her cocoons has been established. One method of contact is to attend provincial and/or state association meetings. Another method is to advertise in farm newspapers in Canada and the United States.

The beekeeper not wishing to be directly involved in marketing may sell cocoons through a leafcutter bee broker. Several such brokers exist in Canada and the United States.

Some producer/marketers use a combination of laminate and drilled-block nesting boxes. Cocoons for their own use are removed from laminates and stored. The surplus cocoons are then marketed into the United States in drilled blocks, which are popular there.

## Ten Points to Remember:

1. Contact seed dealers, experienced growers and extension personnel for information **before** you make any cropping decisions.
2. Inoculate the seed properly, using a sticking agent.
3. Start with clean land, prepare a firm seedbed, and place the seed close to the soil surface.
4. Buy high quality leafcutter bees which are disease- and parasite-free.
5. Store cocoons above 0ºC, preferably in the 5 - 8ºC range.
6. Carefully monitor incubation temperatures.
7. Control parasites and mold problems.
8. Check regularly on field activity.
9. Store nesting boxes at 20ºC for three weeks before cell removal and cool storage.
10. Ensure that cocoons are removed from nesting boxes.

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